Attention Control and Eyesight Focus for Senior Citizens

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Abstract. The population is aging fast and with aging come cognitive impairments that often require costly facility care. This paper proposes Smart Glasses that can help alleviate these impairments at their early stages and thus allow senior citizens stay away from facility care longer. The Smart Glasses produce exogenous cues to attract user attention. Four usability experiments are described to evaluate the utility of the cues and other usability factors of the proposed system. We expect the results will give us valuable information on how to improve the design of the system based on senior citizens' needs.

Keywords: smart glasses, aging in-place, assistive technology, attention control, cognitive impairment.

1 Introduction

Ferri et al. estimated that 24.3 million people suffered from dementia in the year 2005 and 4.6 million people are added to this number every year. It is predicted that number of people suffering from dementia will be about 81.1 in the year 2040. Unobservable cases of dementia should also be added to the estimation. [4]

Abovementioned statistics and estimations have led numerous researchers developing tools and systems to support health care of senior citizen in their home. This concept is known as aging-in-place. Supporting senior citizens' independent daily life and monitoring health, safety, physical and cognitive functionalities are the main purposes to develop new tools and systems. [2]

Common problems for the senior citizens are memory related issues, and range from simple age-related problems to Alzheimer's Disease. A collaborative study in Nordic countries [5] was conducted on individuals with dementia and the goal was to find out what kinds of aid devices are used for assistance, how suitable they were for the users, and to gather improvement feedback for the aid device researchers [8]. Conclusions indicated that introducing aid devices for the caretakers and people suffering from dementia has improved management of daily activities; it helped caretakers and patients to maintain skills and made people socially more active. Prior researches have also suggested that navigation technology has the potential to provide

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important support for the elderly by similarly motivating and empowering them to perform their daily activities. [7]

The ability to achieve and maintain focus of cognitive activity on a given task is a fundamental component of the cognitive capacities of humans. Researches on visual capabilities of the elderly have concluded that aging itself brings along decline in both cognitive abilities and the capabilities of the visual system, added with constraints brought by dementia. [9], [12]

Research on attentional capacity of the elderly [1] suggests that both normal aging and Alzheimer's Disease (AD) impair people's performance in reaction tests but continue to conclude that people in the earlier phases of AD were not significantly more impaired by the increase in difficulty of a given task than the normal elderly. AD patients may have more problems in filtering interference from similar background material. The paper concludes there was no apparent decline in the capacity to divide attention with age, whereas there was a clear impairment in the dual-task performance of AD patients.

Visual performance of humans depends on both operational variables and physical variables. The operational variables include age, visual capabilities (contrast and light sensitivity, color and depth perception) and the characteristics of the task. The physical variables consist of lighting conditions, disability or discomfort glare, and colors in the vicinity, among others. In addition, several cognitive processes affect how information is filtered for processing through the general physical features. Attention has been described as limited by the mental effort available, and the limited cognitive capacity of attention can be actively spread over several cognitive demands at a time. How much attentional capacity and finite processing resources are allocated and needed for each task is determined by a combination of factors. [9]

There is also evidence that endogenous and exogenous cues have separate and additive effects. Endogenous cues allow the participant direct their attention to the indicated location at will, which also implies the symbology of the cues must be understood and their meaning remembered throughout the task. Exogenous cues, such as a flash of light, attract attention automatically. Such a cue is still effective even if the participant's cognitive resources are occupied elsewhere. [13]

We have founded our approach for the Smart Glasses on the premises set by the referenced literature. Section 2 describes the system setup, section 3 explains the test setup and the usability tests we have planned, and Section 4 concludes the paper.

2 Smart Glasses System

The first version of Smart Glasses prototype contains 12 red LEDs and 12 green LEDs as presented in Figure 1, and the second prototype version contains 6 red LEDs and 6 green LEDs as presented in Figure 2. The LEDs are positioned on the frames of Smart Glasses and are controlled by TLC5940 drivers. The drivers are connected to a micro-controller (low-power ATMega168V) via serial communication bus. The commands for different LED patterns are received through the wireless communication module. A Li-ion battery supplies power for the micro-controller. The micro-controller is connected to a Bluetooth Serial Port Profile (SPP) module. SPP module is the communication gateway of the micro-controller and an Android application. SPP is used to send 32-bit control messages from the remote controlling device (Android tablet) to the Smart Glasses. Remote controlling device translates 32-bit control messages to voice commands, and sends them to an audio device via Bluetooth.

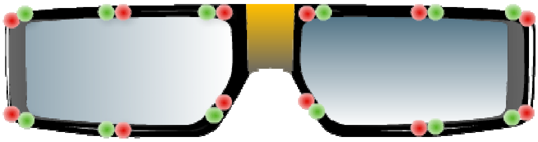

Fig. 1. First prototype version of smart glasses having 12 green LEDs and 12 red LEDs positioned on the frames

Fig. 2. Second prototype version of smart glasses having 6 green LEDs and 6 red LEDs positioned on the frames

3 Usability Test for Smart Glasses

The main objective of conducting usability experiment is to remove blocking and problematic issues from user's path through the application. Problematic issues mostly cause failure in achieving maximum desired application's usability. Analyzing tasks of usability test facilitates designing user interface and application concept more accurately. There should be four to six participants in usability testing to rely on results; a final report should outline findings and provide developers with recommendations to redesign the system. [3], [10]

Usability experiment setting is defined as specific number of participants, a moderator and a set of tasks to test the system. It identifies problems, which have been hidden through the development process from developer's point of view. In order to organize usability testing before conducting it, a set of assumptions should be predefined, and then assumption should be evaluated after the usability testing. [6], [11]

In order to measure usability in experiment, it is necessary to define following factors:

- Effectiveness means user's ability to accomplish tasks.
- Efficacy means user's ability to accomplish tasks quickly without difficulty and frustration.

- Satisfaction means how much user is enjoying doing tasks.
- Error frequency and severity means how often user makes errors and how serious are the errors.
- Learnability means how much user could learn to use the application after doing the first task.
- Memorability means how much user could remember from one task during next tasks.

Separate tasks could be designed to evaluate different usability factors. [6], [11]

3.1 Test Setting

Subjects in all the experiments will be senior citizens suffering from dementia, and people suffering from other illnesses like color-blindness, tinnitus or Parkinson's Disease potentially affecting their performance in the tests will be excluded. The minimum number of participants in each experiment will be four. An observer representing the medical center will be present in all the experiments.

In order to evaluate satisfaction properly, the observer will be advised to encourage participants to think aloud during the experiment and give feedback to observer at the end of each experiment. Qualitative questionnaires will be presented after each experiment to collect participants' satisfaction and preferences.

One video camera will be used to record participants' actions and another video camera will be used to record their eye movements during the tests. The recordings will be synchronized and time-stamped, which will help to investigate the sequence of events properly.

Different kinds of test applications on an Android tablet will be used to record the results and log other necessary information on the experiments. These tools accompanied with the qualitative questionnaires will help us to investigate effectiveness, efficacy, satisfaction and learnability of the system.

3.2 Test Scenarios

We have defined four usability tests to evaluate usability factors of Smart Glasses system. The foremost purpose will be to establish the feasibility of the designed Smart Glasses for the indoor and outdoor navigation scenarios. The second objective will be to measure usability factors that can have either strengthening or weakening effect on the design. Salient factors are effectiveness, efficacy, satisfaction and learnability of the system.

The first test will focus on finding the best way the system can attract participant's attention. In the second test we will be asking the participants' opinion of the best pattern for indicating all possible directions. The third test will tell us how well the navigation instructions given by the Smart Glasses can be followed by the participant by moving their finger on a tablet PC to the direction indicated. Finally, the fourth set of tests will be first conducted in open space indoors where the participant is walking through a predefined route with the help of the Smart Glasses. This test will also be repeated in open space outdoors to capture how the changes in ambient light and sounds will affect the usability of the Smart Glasses.

The first test is designed to identify how accurately senior citizens can recognize precisely which LED on Smart Glasses is lit or blinking. At the same time, this test aims to identify how accurately senior citizens can recognize the general direction in which the LED on Smart Glasses is lit or blinking. The directions are defined as lighting up a single LED or a combination of LEDs depending on the Smart Glasses prototype version. A test application for the tablet PC will be developed to store participants' responses. Participants will be divided into two groups, one having the prototype version with six LEDs per lens and the other having three LEDs per lens. A number of sequences for lighting up the LEDs will be defined beforehand and the sequences are used in tests randomly in order to avoid any learning effect from one test to another. By comparing the results obtained from tests with different LED configurations we hope to be able to define the specific number and configuration of LEDs per lens that yields the best results. After identifying the most suitable pattern of LEDs per lens on the Smart Glasses, two further experiments will be conducted.

In the second test, we will present the participants with all feasible LED combinations for a given direction. We will then ask their opinion on which particular pattern they would associate the best with the specific direction in question.

The third test will incorporate a Bluetooth headset to accompany the Smart Glasses. In addition, a tablet PC with a stylus and two cameras will be utilized. An application running on the tablet PC will communicate with the Smart Glasses and headset via Bluetooth. The application user interface is designed as a grid layout with invisible lines and it will include a specific number of cells. The operator selects a route from predefined set of routes to follow. A route is a set of adjacent cells (Figure 3), having a starting point and an endpoint. When participant moves the pen on the screen from a cell to another cell, the application recognizes if the pen is moving along the route or not. The application calculates the next movement direction based on the current position of the pen and its relation to the next cell in the route. After a specific time delay, a new direction indication is sent to Smart Glasses and headset. If participant makes an error and moves the pen to a cell outside the route, the application will provide a direction indication towards the nearest cell in the route. The application will guide the participant periodically to reduce the amount of errors during the usability testing. To evaluate intuitiveness and learnability of the system, this test will be conducted in three different variations. The guidance can be audio only, LEDs and audio or LEDs only. By evaluating the results, we will also be able to determine whether the modalities support or hinder each other with participants being cognitively impaired.

The fourth and last test is a navigation experiment to guide the users through a specific route in both an indoor and an outdoor environment. The routes will be predefined and contain a fixed number of turns to each direction and predetermined length. Participants will be randomly assigned a route from the set. These navigation tests will not only evaluate usability of the system under more realistic conditions, but also evaluate the influence of ambient light on visibility of the LEDs and the effect of ambient sounds from the environment to the audio-cues.

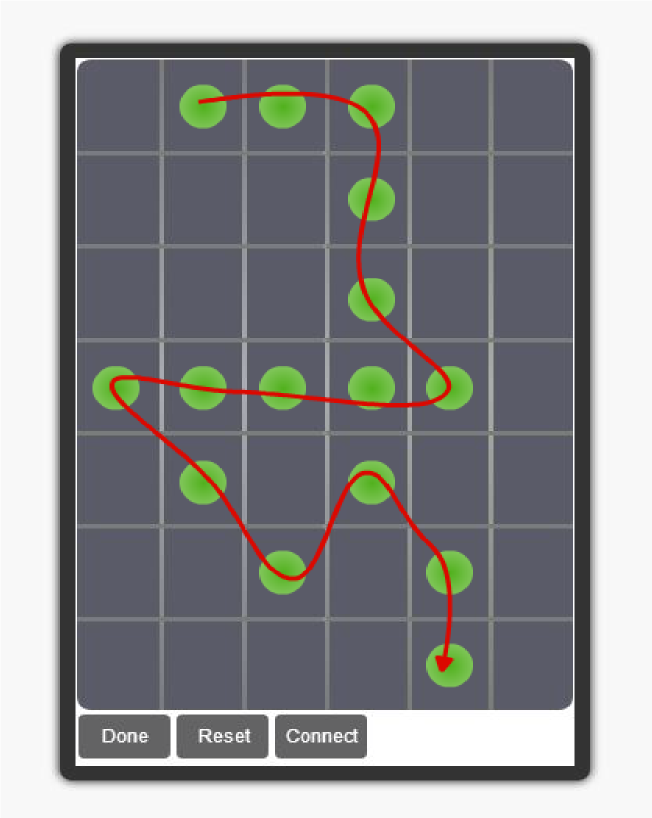

Fig. 3. A predefined route in the third test contains a sequence of cells (gridlines are not visible for the participants)

4 Conclusion

In this paper, we have described our Smart Glasses approach to assist senior citizens in their daily activities. Four usability tests have been defined to evaluate usability factors of the system. We will be conducting the tests in the next few months and report the results on HCII 2014. During the testing, we will iterate over the design for the Smart Glasses based on test results and participant feedback.

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References

1. Baddeley, A.D., Baddeley, H.A., Bucks, R.S., et al.: Attentional Control in Alzheimer's Disease. Brain 124, 1492–1508 (2001)
2. Bharucha, A.J., Anand, V., Forlizzi, J., et al.: Intelligent Assistive Technology Applications to Dementia Care: Current Capabilities, Limitations, and Future Challenges. The American Journal of Geriatric Psychiatry: Official Journal of the American Association for Geriatric Psychiatry 17, 88 (2009)
3. Donahue, G.M., Weinschenk, S., Nowicki, J.: Usability is Good Business. Verfügbar unter (1999) (April 24, 2003), http://www.yucentrik.ca/usability.pdf
4. Ferri, C.P., Prince, M., Brayne, C., et al.: Global Prevalence of Dementia: A Delphi Consensus Study. The Lancet 366, 2112–2117 (2006)
5. Hyry, J., Yamamoto, G., Pulli, P.: Requirements Guideline of Assistive Technology for People Suffering from Dementia, 39 (2011)
6. Jeng, J.: Usability Assessment of Academic Digital Libraries: Effectiveness, Efficiency, Satisfaction, and Learnability. Libri. 55, 96–121 (2005)
7. Kangas, M., Konttila, A., Lindgren, P., et al.: Comparison of Low-Complexity Fall Detection Algorithms for Body Attached Accelerometers. Gait Posture 28, 285–291 (2008)
8. Kangas, M., Vikman, I., Wiklander, J., et al.: Sensitivity and Specificity of Fall Detection in People Aged 40 Years and Over. Gait Posture 29, 571–574 (2009)
9. Kretschmer, V., Griefahn, B., Schmidt, K.-H.: Bright Light and Night Work: Effects on Selective and Divided Attention in Elderly Persons. Light Res. Technol. 43, 473–486 (2011)
10. Nielsen, J.: Usability Inspection Methods, 413-414 (1994)
11. Sauro, J., Kindlund, E.: A Method to Standardize Usability Metrics into a Single Score, 401-409 (2005)
12. Staub, B., Doignon-Camus, N., Després, O., et al.: Sustained Attention in the Elderly: What do we Know and what does it Tell Us about Cognitive Aging? Ageing Res. Rev. 12, 459–468 (2013)
13. Tales, A., Muir, J.L., Bayer, A., et al.: Spatial Shifts in Visual Attention in Normal Ageing and Dementia of the Alzheimer Type. Neuropsychologia 40, 2000–2012 (2002)